RESEARCH DEPARTMENT

The AKG Electrostatic Microphone Type C 12

Report No. M.026

Serial No. 1954/41

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

B.B.C. Research Department

ERRATUM

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The paragraph below should be fixed in position to cover the third paragraph on page 2 (sub-section "2.1. General")

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CONFIDENTIAL

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SUMMARY

A new electrostatic microphone, type C 12, has been produced by the firm of Akustische und Kino-Geräte Gesellschaft in Vienna. The nominal polar characteristic of the microphone can be varied from omnidirectional through cardioid to a figure-of-eight by a multi-position remote control switch. Frequency response, sensitivity and noise have been measured on a single specimen for these three conditions.

The microphone has a wide frequency range. In the omnidirectional condition, the frequency characteristics are fairly smooth; in the cardioid condition, not only is the axial frequency characteristic very smooth but the variation in directional characteristic with frequency is less than is usual for this class of microphone. With a little equalisation at high frequencies the figure-of-eight condition would yield a nearly level response.

1. INTRODUCTION.

The C 12 is an electrostatic type of microphone made in Vienna by Akustische und Kino-Geräte Gesellschaft.

The microphone capsule has a diaphragm on each side of a perforated electrode and the directional characteristic is varied by changing the relative polarisation of the diaphragms. This method of operation is similar to that of the M 49 made by Messrs. Neumann of Berlin and described in the technical press[1]. A nine-position remote control switch gives a choice between omnidirectional, cardioid, figure-of-eight or intermediate characteristics. Since the polarising circuit has a time constant of approximately 5 sec, the transition from one condition to another is effected without switching clicks; the polar characteristic may therefore be safely altered during a transmission.

A specimen has been in service for several months and has been tested at the request of S.S.E., H.S.B.

2. DESCRIPTION OF MICROPHONE.

2.1. General.

Fig. 1 shows the appearance and dimensions of the instrument which, being long and narrow, is more suitable for television purposes than some other types. The casing is plated, the central portion being matt and the remainder polished. Fig. 2 shows the circuit diagram. The transformer may be connected to give a nominal output impedance of 40 ohms, 250 ohms or 500 ohms. For the tests described the 250 ohm connection was used.

In this type of microphone, perforations in the central electrode form resistances which with the volume of air between the diaphragms form a phase changing network; the constants must be accurately adjusted to obtain a cardioid characteristic. In the type C 12 this adjustment is facilitated by constructing the central electrode in the form of two disks separated by a narrow gap. The perforations in the two disks are intentionally placed out of alignment; air flowing between the two diaphragms must therefore pass laterally through the narrow central gap, the flow resistance of which can be varied on test by altering the gap spacer. The capsule is attached to the top of the amplifier by a resilient mounting which considerably reduces the effects of vibration. The resilience is so large that when the microphone amplifier axis is horizontal, the capsule takes up a different position in relation to the casing, causing a change in response of approximately 1 dB at high frequencies. Mechanical protection and electrical screening are afforded by an outer case of fine wire gauze sandwiched between two layers of coarse gauze.

The microphone is connected by a plug and 65 ft (20 m) cable to the polar diagram selector switch shown in Fig. 1, and thence by a 32 ft (10 m) cable to the mains unit also shown in the same figure. The audio-frequency output is taken from the mains unit through a three-pin plug and socket.

2.2. Weight.

Weight of microphone	1 lb 7 oz (0·65 Kg)
Weight of selector switch	1 lb 7 oz (0·65 Kg)
Weight of mains unit	7 lb 12 oz (3·5 Kg)

3. PERFORMANCE.

3.1. Method of Measurement.

The frequency characteristics were measured by comparison with a pressure standard in a non-reverberant room, except at frequencies below 200 c/s, for which the measurements were made in a plane-wave duct. The accuracy of comparison with the standard was in general $\pm \frac{1}{2}$ dB, but in the cardioid condition for sound at angles of incidence greater then $\pm 90^{\circ}$, errors up to ± 1 dB would be possible. The characteristics of the standard are known to within $\pm \frac{1}{2}$ dB.

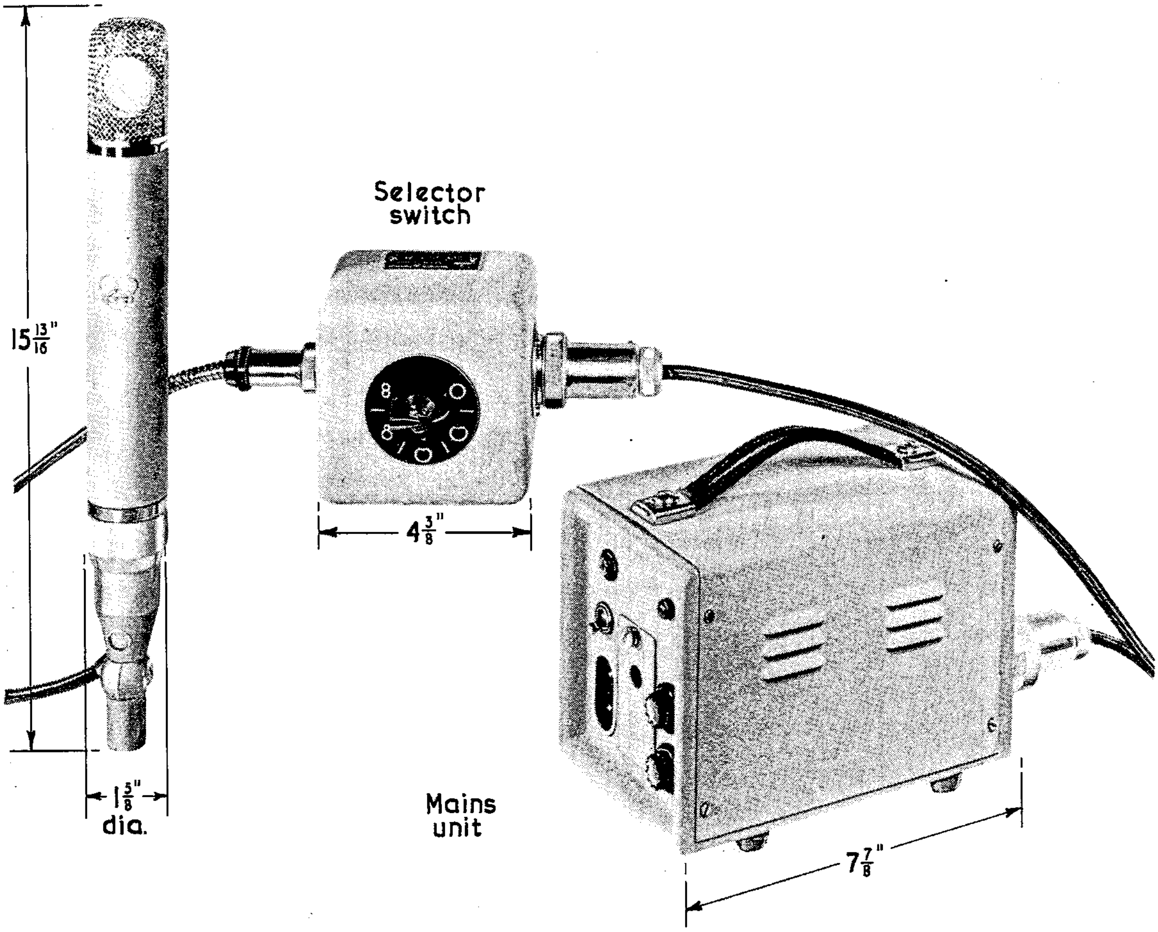

Fig.1

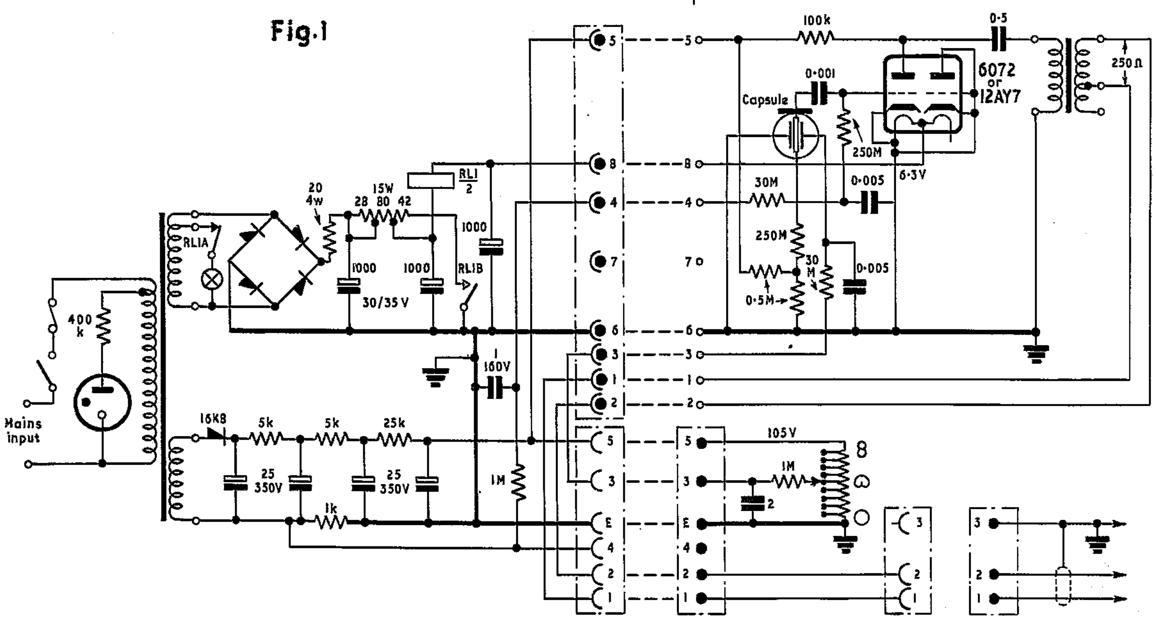

Fig. 2 - Circuit diagram

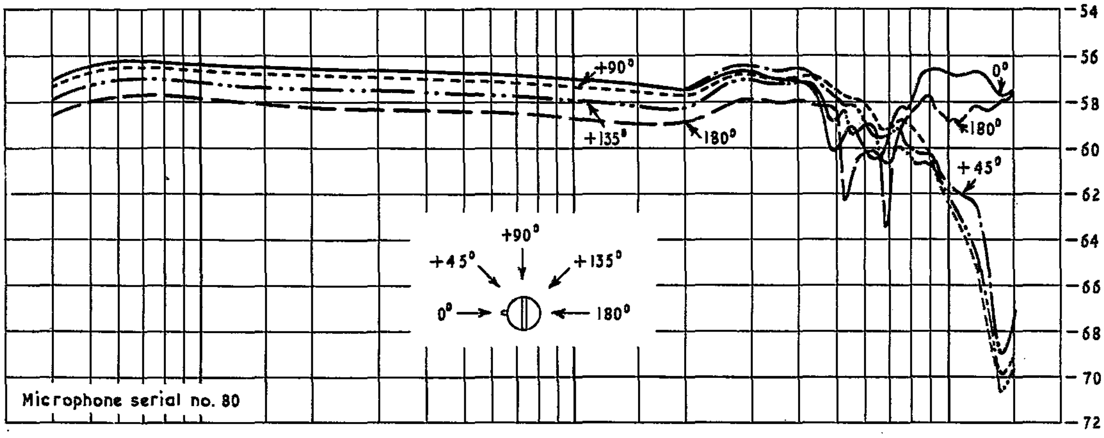

Fig. 3 - Frequency characteristics in horizontal plane
Omnidirectional condition

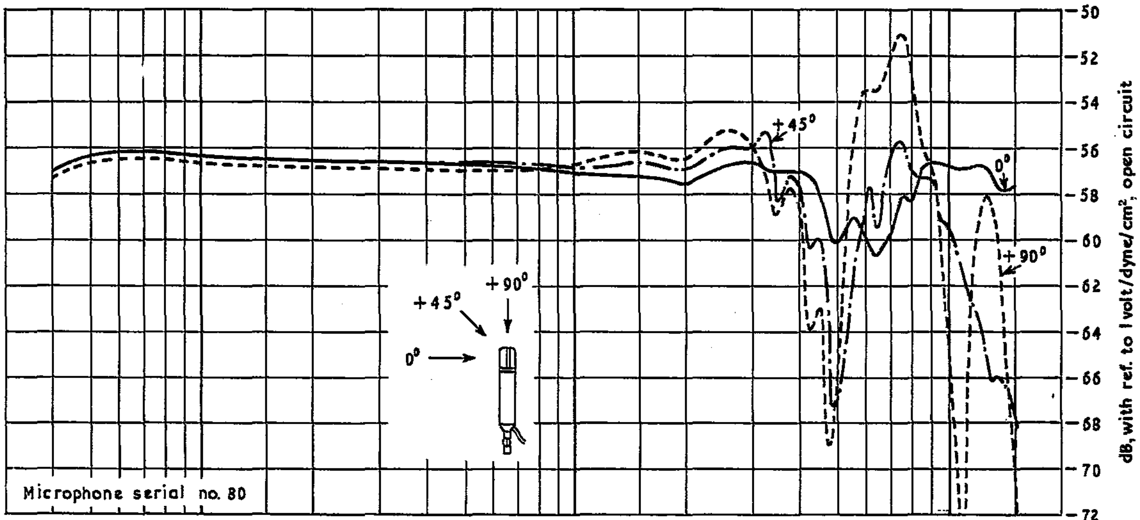

Fig. 4 - Frequency characteristics in vertical plane above axis
Omnidirectional condition

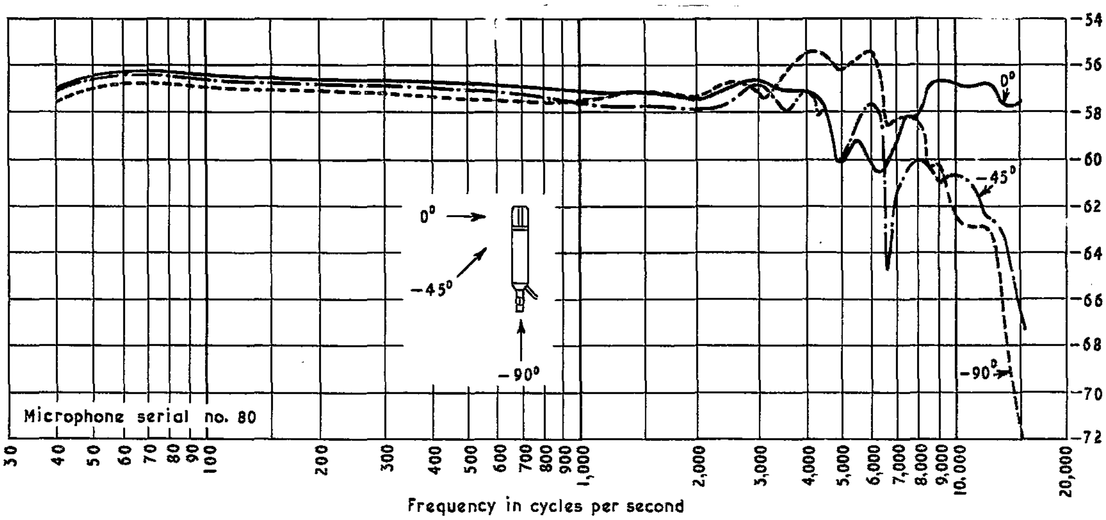

Fig. 5 - Frequency characteristics in vertical plane below axis
Omnidirectional condition

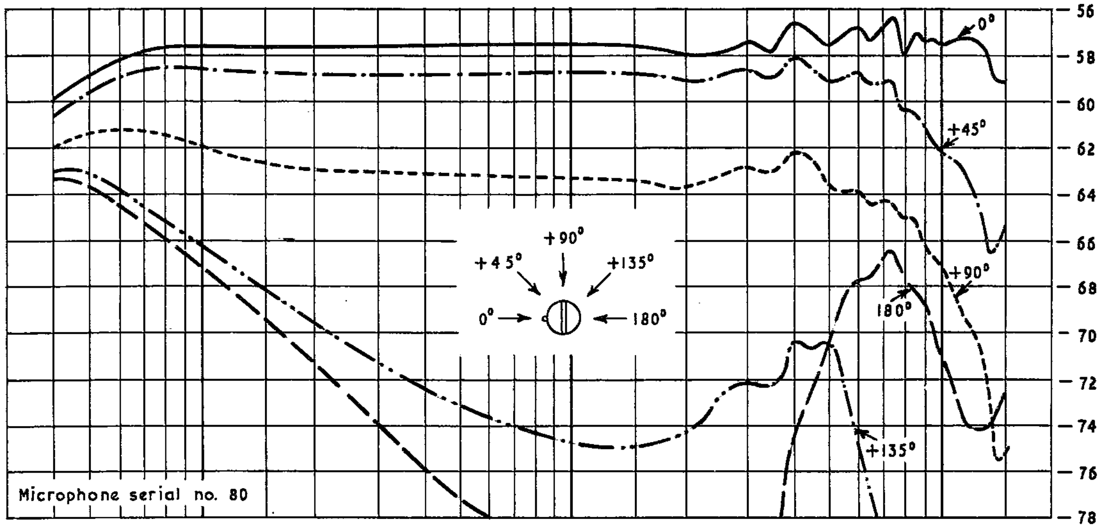

Fig. 6 - Frequency characteristics in horizontal plane Cardioid condition

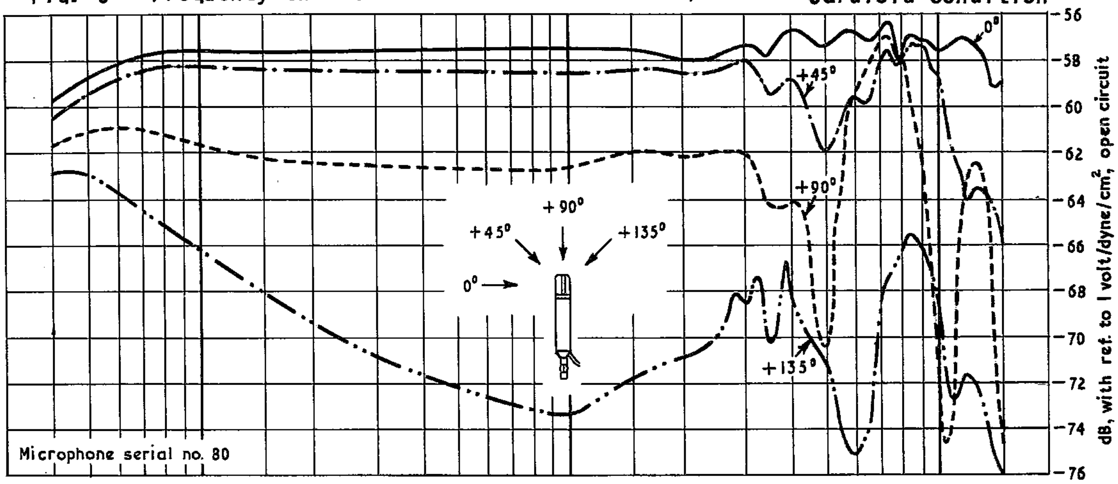

Fig. 7 - Frequency characteristics in vertical plane above axis Cardioid condition

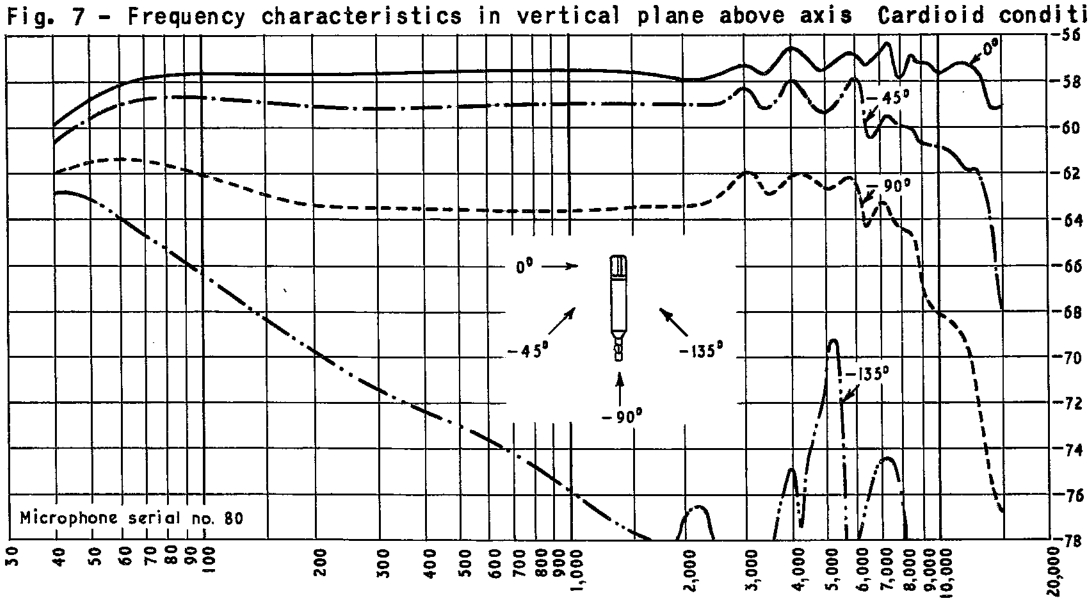

Fig. 8 - Frequency characteristics in vertical plane below axis Cardioid condition

3.2. Frequency Characteristics.

Figs. 3, 4 and 5 show the open-circuit frequency characteristics of the microphone in the omnidirectional condition for sound incident at various angles in the horizontal and vertical planes. Figs. 6 to 8 and Figs. 9 and 10 show the corresponding plane-wave characteristics for the cardioid and figure-of-eight conditions. The irregular nature of the 90° curves of Figs. 4 and 7 for frequencies above 4 kc/s is due to interference between the direct sound wave and that reflected from the head amplifier. The effect of interference is obvious even though the diameter of the head amplifier is much smaller than that in other comparable microphones such as the Neumann type U 47[2]. In the figure-of-eight condition (Fig. 10) there is no corresponding curve because of the null in the polar characteristic.

The axial response in the omnidirectional condition, Figs. 3 to 5, is very well maintained at both ends of the frequency band but there is a dip of nearly 4 dB centred about 6 kc/s followed by a sharp rise to 9 kc/s. The front and back responses differ slightly, even at low frequencies. This effect, which has not previously been encountered in a nominally omnidirectional microphone, appears to be due to

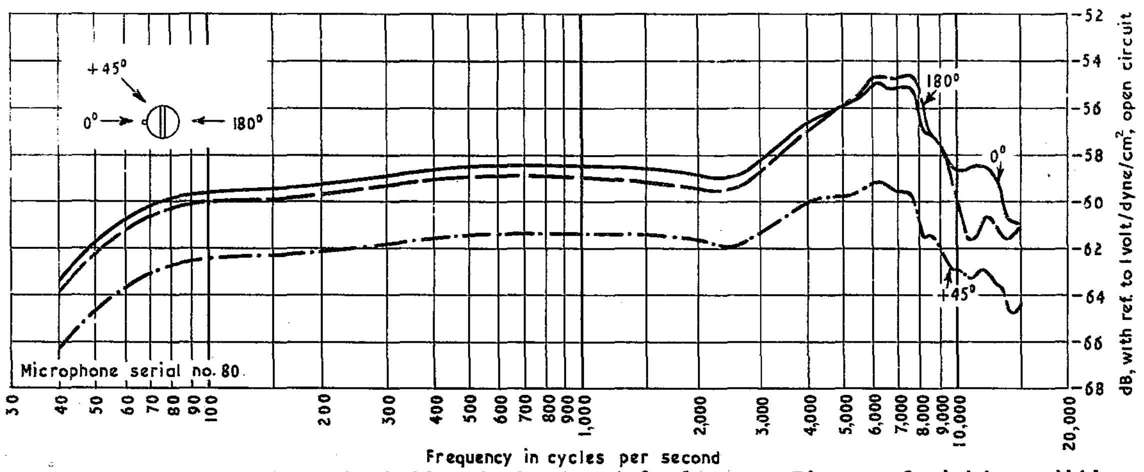

Fig. 9 - Frequency characteristics in horizontal plane. Figure-of-eight condition

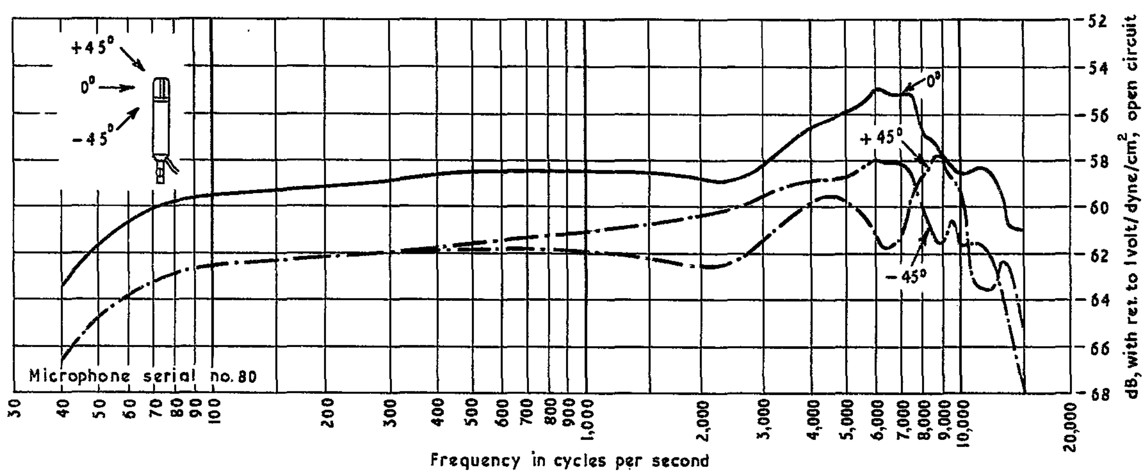

Fig. 10 - Frequency characteristics in vertical plane. Figure-of-eight condition

some slight asymmetry in the capsule; in the present instance, it is for practical purposes negligible.

In the cardioid condition, Figs. 6 to 8, the curve of the axial frequency response is very smooth. The directional properties of the capsule remain fairly uniform over the high-frequency range except in the region between 6 kc/s and 9 kc/s, where the difference between the 0° and 180° response falls to about 10 dB.

The tendency, common in double-diaphragm "cardioid" microphones, for the directional characteristic to degenerate at low frequencies into a circle is less pronounced in the C 12 than in other microphones of its class. This improvement appears to have been produced by increasing the acoustic resistance presented to the rear diaphragm.

In the figure-of-eight condition, Figs. 9 and 10, the sensitivity falls at low frequencies; at high frequencies the response, although well maintained up to 13 kc/s, rises between 4 kc/s and 8 kc/s to a maximum 4 dB above the mid-band level.

The mid-band impedance of the microphone, when using the 250 ohm transformer connection, is approximately 300 ohms; the value is substantially constant throughout the audio-frequency band so that the on-load frequency characteristics do not differ significantly from those shown.

3.3. Sensitivity.

Unlike other types of variable-directivity microphones tested, the axial sensitivity is nearly independent of the setting of the polar characteristic control; this is an important advantage if the control is to be operated during a transmission.

In the mid-band region the open-circuit sensitivity of the microphone is −57 dB relative to 1 volt/dyne/cm² for the omnidirectional and −58 dB for the cardioid and figure-of-eight conditions. The manufacturers' figure is −54 dB.

For comparison the sensitivity of the type AXBT is −71 dB relative to 1 volt/dyne/cm².

3.4. Noise.

3.4.1. General.

The electrical noise output of the microphone is a combination of flicker effect in the valve and thermal agitation in the resistive component of the grid circuit impedance. Both sources have a spectrum of roughly constant power per octave throughout the audio-frequency band.

The open-circuit noise when weighted by an aural sensitivity network type ASN/3 is −104 dB relative to 1 volt. The mid-band sound pressure required to give the same output level is +28 dB relative to 0·0002 dyne/cm². For comparison, the corresponding figure for the type U 47[2], a similar microphone, in the cardioid condition is +16 dB, and for the type AXBT +18 dB. The difference between the types C 12 and U 47 is almost entirely due to the lower sensitivity of the type C 12 micro-

phone capsule; this in turn is caused by the additional resistive control[1] which appears to be necessary to obtain the improved directional characteristics at low frequencies.

3.4.2. Interference from Magnetic Fields.

The maximum open-circuit induction generated in the microphone by a uniform magnetic field was measured. The mid-band sound levels, with reference to 0·0002 dyne/cm^2, required to give an output equivalent to that produced by a uniform magnetic field of 1 milligauss at 50 c/s; 1 kc/s and 10 kc/s are +29 dB, +25 dB and +30 dB respectively; for comparison, the corresponding figures for a typical AXBT are +12 dB, +24 dB and +38 dB.

4. LISTENING TESTS.

Speech tests were carried out using male voices in acoustically dead surroundings and listening on a wide range loudspeaker. The general standard of microphone performance was very high. In the omnidirectional condition the quality tended to sound "spiky" at high frequencies. In the cardioid condition the axial response was described as a little "gritty", this effect disappearing when the sound was incident at 90° in the horizontal plane. In the figure-of-eight condition a slight bass loss was noticeable and the high frequencies were rather prominent. Other listening tests were carried out in collaboration with S.S.E., H.S.B.'s Staff in an orchestral studio. Under these conditions the slight hardness in high frequency response was not so noticeable.

5. CONCLUSIONS.

The frequency characteristics of the type C 12 are the best so far measured for this type of microphone.

In the omnidirectional condition the response is very level but would be improved if the irregularity around 6 kc/s were removed. The effect of "spikiness" noticed in speech transmitted from a non-reverberant room was probably due to the fall in the 5 to 7 kc/s region followed by the sharp recovery at 9 kc/s.

The cardioid condition is of particular interest since very few microphones maintain such a characteristic over the whole of the audio-frequency band. In this condition the axial response curve of the type C 12 is particularly smooth and extends up to over 15 kc/s. The directional properties at both ends of the audio-frequency band are closer to the nominal than is usual for a double diaphragm type of instrument. The greater resistive control necessary to achieve this improved performance results in a signal-to-noise ratio which is lower than that of some other directional electrostatic microphones but is still adequate.

In the figure-of-eight condition the response from 6 to 8 kc/s is 4 dB higher than in the mid-band, and would be improved by equalisation. By means of a single inductance-capacity circuit the axial response could be made uniform within ± 1 dB from 100 c/s to 13 kc/s. An additional wafer could be attached to the polar selector switch to bring the equaliser into circuit as required.

Interference due to extraneous magnetic fields is low at 50 c/s and extremely low at 1 kc/s and 10 kc/s.

The small size and shape of the microphone compared with other microphones of the same type give it an advantage in television. It appears however that the head amplifier is not small enough to avoid degrading the response to sound incident at +90° in the vertical plane.

6. REFERENCES.

1. F.W.O. Bauch, "New High-Grade Condenser Microphones", Wireless World, No. 59, March 1953, pp 111-114.

2. Research Department Report No. M.020, Serial No. 1954/23, "The Neumann Microphone Type U 47".